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PROJECT PLANNING AND PROJECT MANAGEMENT OF BASEBALL II-T

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Summary

The purpose of this paper is to review the details of the project planning and project management work done on the Baseball II-T experiment. The LLL Baseball program is a plasma confinement experiment accomplished with a superconducting magnet in the shape of a baseball seam.

Both project planning and project management made use of the Critical Path Management (CPM) computer code.[1] We describe in detail the computer code, input, and results from the project planning and project management runs, and discuss the cost and effectiveness of this method of systems planning.

CPM Computer Code

The Critical Path Management (CPM) computer code schedules the allocation of resources in the following ways: when two or more tasks are competing for the same resource, the most critical task is scheduled first. As more of the particular resource or craft becomes available, the next most critical task is scheduled. The most critical path is the sequence of tasks which has the longest time from start to completion. The tasks associated with this critical path are the most critical and have a "float" of 0.0. Any task connected to a critical path, but which has a duration less than that of another task connected to the the same nodes, will have a float (in weeks) equal to this difference in duration. Therefore, a float of 2.0 indicates the task with this float can be delayed for two weeks without delaying the project completion date.

Each node (a point separating activities on the flow chart) has two calendar dates associated with it; the earliest and latest date that this node can be reached. The tasks have associated with them an activity (a description of the work to be done), the duration of the activity in calendar weeks, the manpower density during this activity, the type of manpower (craft), the person responsible, and the capital cost.

Before making the initial input, a rough node chart showing at least the major subsystems should be constructed. This, along with the desired completion dates for some of the tasks, will make the input somewhat easier. For input, all the information associated with each task must -- defined. An example of the typical input is shown in Fig. 1.

The output consists of data sorted by various methods and a new sch- ile of the tasks and nodes when the scheduling option - employed. Tasks may be sorted by:

- craft code
- late completion time
- early completion time
- late start time
- early start time
- the person responsi

Sorting by both early star and late completion allows the determination of the t within which a task can be completed. This is hel if more than one task is competing for the same res e because a time-sharing of that resource is possibl t neither task will be delayed beyond the late completion time. This is where the "float" is determined: defined as the number of weeks that completion of a particular task can be delayed without delaying the project completion date. The scheduling option is employed by assigning priority either to the task with the least float or to the task requiring the greatest number of man-days to complete. The scheduling, completed after the priorities have been set, can be done either by increasing the critical-path length to remain within the limits of available manpower or by temporarily exceeding the manpower limits to keep the project on schedule.

In addition to the shorting and scheduling options, the CPM program also produces a CPM node and activity chart (on the CalComp plotter), a manpower density chart, and a project bar chart. Additional information concerning the running of the computer code can be obtained in Refs. 1, 2, and 3. Typical output was generated during both the project management and project planning computer runs and is shown below.

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"Reference to a company or product name does not imply approval or recommendation of the product by the University of California or the U.S. Energy Research and Development Administration to the exclusion of others that may be suitable.

A	B	C	D	E	F	G	H
1332	1482	3.00	0.50	4	FRANK	X-RAY DETECTOR	1.20
1262	1362	2.00	0.50	6	FRANK	X-RAY DETECTOR	0.70
1382	1482	2.00	0.50	7	FRANK	X-RAY DETECTOR	0.60
1482	1582	2.00	0.50	7	FRANK	X-RAY DETECTOR	0.60
1582	336	-0.	-0.	-0			-0.
226	1083	-0.	-0.	-0			-0.
1083	1183	2.00	0.80	3	CHARG	SURFACE BARRIER DETECTOR	1.50
1183	1283	2.00	0.80	3	CHARG	SURFACE BARRIER DETECTOR	1.50
1283	1383	2.00	0.80	3	CHARG	SURFACE BARRIER DETECTOR	1.50
1183	1283	2.00	0.20	8	CHARG	SURFACE BARRIER DETECTOR	0.40
1283	1483	3.00	0.20	8	CHARG	SURFACE BARRIER DETECTOR	0.60
1183	1283	1.00	0.50	4	CHARG	SURFACE BARRIER DETECTOR	0.40
1283	1383	2.00	0.50	4	CHARG	SURFACE BARRIER DETECTOR	0.80
1383	1483	2.00	0.50	4	CHARG	SURFACE BARRIER DETECTOR	0.80
1483	1583	3.00	0.50	4	CHARG	SURFACE BARRIER DETECTOR	1.20
1383	1483	2.00	0.50	5	CHARG	SURFACE BARRIER DETECTOR	0.90
1483	1583	2.00	0.30	6	CHARG	SURFACE BARRIER DETECTOR	0.40
1583	1683	1.00	0.30	6	CHARG	SURFACE BARRIER DETECTOR	0.20
1583	1683	3.00	1.00	7	CHARG	SURFACE BARRIER DETECTOR	1.80
1683	336	-0.	-0.	-0			-0.
226	1084	-0.	-0.	-0			-0.
1084	1184	2.00	0.50	3	DENHOYLOW	ENERGY ION SPECTROMETER	0.90

Fig. 1. Example of computer input: A, starting node for activity; B, end node for activity; C, duration of activity in calendar weeks; D, manpower density during the activity; E, craft code (each member is associated with a particular function, e.g., craft code 3 is mechanical engineering); F, person in charge of this task; G, activity title; and H, activity cost.

Project Planning

The project planning runs were made for the second phase (beam line rework for multiple injection of neutral beams) of the Baseball II-T program. The first phase of the Baseball II-T program was well underway when this CPM technique was undertaken, and it was decided to use the management techniques until the work was completed. The project planning runs for the second phase used a January 1975 start date for planning purposes only, however, this phase is just now starting.

Four important goals, necessary to most planning decisions of major projects, were accomplished during the project planning runs. These are:

- categorizing the elements important to project completion;
- defining all important tasks and craft codes necessary for each project element;
- timing each major element with respect to the rest of the project;
- and eliminating large peaks or valleys of any craft code manpower density.

Relatively small peaks or valleys are tolerable, because they can most likely be absorbed by other projects in the division. The first three goals are started by organizing the project for computer input. The last goal is attained by rerunning the computer code with slight shifts in the tasks until the manpower densities are fairly smooth. Small valleys and peaks can also be handled by more specific craft codes in the project management runs.

For the multi-beam injection systems, we defined four major subsystems necessary to project completion: multi-beam injection line, beam source, cryopumping, and magnet heat shield. For each subsystem we estimated the major tasks (approximately 30 total) to be completed, and the manpower and money necessary to complete the design, fabrication, and assembly. For budgetary purposes, we separated the fabrication into *inhouse fabrication*, *outside fabrication*, and equipment.

The project planning runs were continued until the peak manpower density for engineering and assembly were within the current limits of the project team. This particular technique delayed the project completion date; however, it is a good starting basis for future project management runs. In the project management runs, more specific tasks and craft codes are defined, and the projected completion date may be closer to the desired date. *Figure 2* is a typical final node flow chart. The total manpower density chart (reconstructed from the computer manpower density charts) for the second phase of the Baseball II-T project is shown *as Fig. 3*. The large valley shown in *Fig. 3c* was unavoidable when the subsystems were combined. However, when the project management runs are made, more specifically defined tasks and other machine operations will alleviate this problem.

The CPM output from the project planning runs has useful information as to the timing of the overall project and the timing of the major milestones. Also important in project planning is the cost in manpower and dollars for each fiscal year if the project runs over one year. This information is useful for moving major tasks backward or forward in time to accommodate any budgetary or manpower increases or limitations.

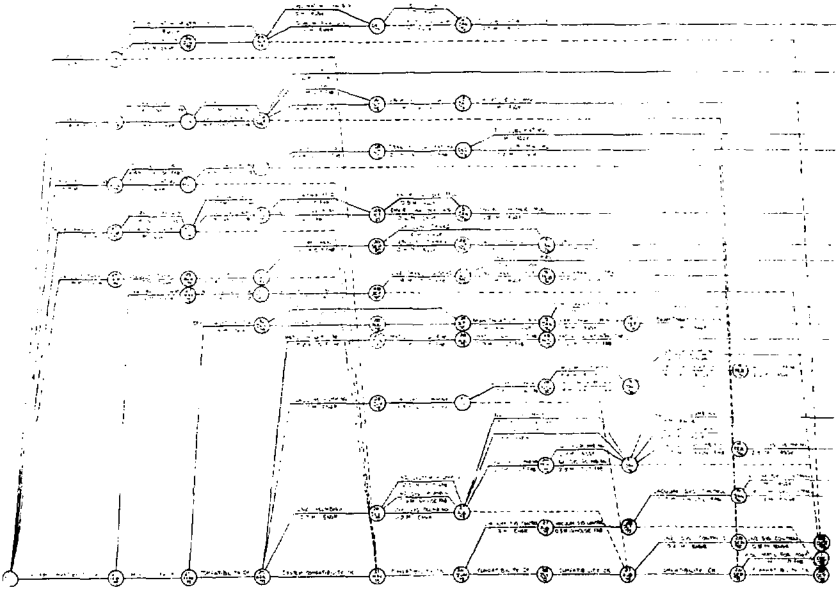

Fig. 2. Typical node flow chart.

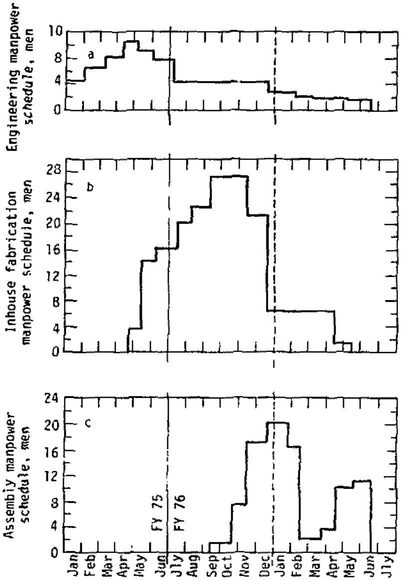

Fig. 3. Total manpower density charts.

The output from the projett planning runs is used by the project planner for a general project overview, such as reporting the project plan, and for organizing the project to meet completion dates. The output from the *final project planning* run can be used as the initial guide lines for the project management runs because the completion dates, milestones, and manpower densities are the same.

Project Management

The computer-generated results from the project management runs are used entirely for scheduling men and dollars to meet the goals and milestones of the project planners. The tasks and craft codes for the project management runs must be more specific than those in the project planning runs; therefore, we adapted a craft code and node numbering system to stay within the limits of the computer program. Early in the project management runs, we decided to work only with the fiscal year 1975 budget and manpower constraints for the project. We let the completion dates of the task float to meet these constraints where possible. But, when it was impossible to complete a task within the time and budget limits, we generally let its completion date float into the next fiscal year. For the early runs, we used the scheduling technique where the project would be delayed to stay within the manpower limits. We continually shifted the least important tasks toward the end of the project and set a new completion date about a third of the way through the current (1976) fiscal year. Then, the scheduling option used was to temporarily exceed the manpower limits to keep the project on schedule. Only in a few cases, and then slightly, were the manpower limits exceeded. This was a result of the shifting and rescheduling of jobs done in the early runs. The priority option throughout was to schedule the jobs on the basis of the least float (most critical) first. The money for the entire project generally followed the budget limits during the final runs.

Both the input and output of the computer runs are discussed below. The input generation is used by the project managers to organize the tasks important to a particular element and to schedule their order to meet the project completion dates. It is also important for delegating authority to the supervisors of the individual tasks and their activities to estimate the manpower needed to meet the completion dates. The output is then used to determine the float of each job.

Input

For the first fiscal year of the Baseball II-T refit and construction, we decided 90 tasks were important to the project completion. For these 90 tasks, we specified over 1,100 activities (e.g., electric engineering for hv cage, mechanical engineering for D to C platform, and assembly of view port) based on the following 10 craft codes (*Table I*):

TABLE I

Craft Code	Description
1	C and M
2	Mechanical technicians
3	Mechanical engineering/design
4	Material fabrication
5	Electrical engineering/design
6	Electrical technician
7	Operators
8	Outside fabrication
9	Equipment
10	Steady state requirements/physics

With the craft codes defined, we next made a node schedule which would allow us to easily update any activity or change its completion status for the next input. A section of the node schedule is shown in Fig. 4. We used three levels of nodes, each more specific than the one below it.

The first-level nodes are comprised of either one or two-digits, which signify the calendar week of the project. The tasks that run between two first-level nodes include the steady-state operations (e.g.,

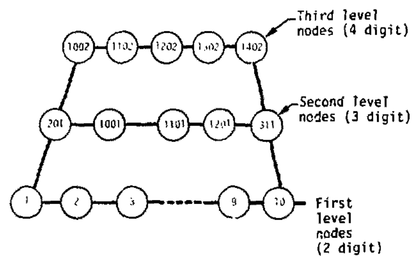

Fig. 4. Section of a node schedule.

68	69	1.00	8.00	10	DAMM	EXPERIMENTAL PHYSICS	7.30	
69	70	1.00	8.00	10	DAMM	EXPERIMENTAL PHYSICS	7.30	
70	71	1.00	8.00	10	DAMM	EXPERIMENTAL PHYSICS	7.30	
71	72	1.00	8.00	10	DAMM	EXPERIMENTAL PHYSICS	7.30	
72	73	1.00	8.00	10	DAMM	EXPERIMENTAL PHYSICS	7.30	
73	74	1.00	8.00	10	DAMM	EXPERIMENTAL PHYSICS	7.30	
74	75	1.00	8.00	10	DAMM	EXPERIMENTAL PHYSICS	7.30	
75	76	1.00	8.00	10	DAMM	EXPERIMENTAL PHYSICS	7.30	First level nodes
76	77	1.00	8.00	10	DAMM	EXPERIMENTAL PHYSICS	7.30	
77	78	1.00	8.00	10	DAMM	EXPERIMENTAL PHYSICS	7.30	
78	79	1.00	8.00	10	DAMM	EXPERIMENTAL PHYSICS	7.30	
79	80	1.00	8.00	10	DAMM	EXPERIMENTAL PHYSICS	7.30	
80	81	1.00	8.00	10	DAMM	EXPERIMENTAL PHYSICS	7.30	
81	82	1.00	8.00	10	DAMM	EXPERIMENTAL PHYSICS	7.30	
82	83	1.00	8.00	10	DAMM	EXPERIMENTAL PHYSICS	7.30	
83	4000	-0.	-0.	-0			-0.	
1	201	-0.	-0.	-0			-0.	
8	211	-0.	-0.	-0			-0.	
20	221	-0.	-0.	-0			-0.	
32	231	-0.	-0.	-0			-0.	
301	10	-0.	-0.	-0			-0.	Second level nodes
311	33	-0.	-0.	-0			-0.	
321	38	-0.	-0.	-0			-0.	
331	43	-0.	-0.	-0			-0.	
201	1001	-0.	-0.	-0			-0.	
1001	1101	3.00	0.20	13		ENLARGE PORT LN2 LHE LINERS	0.85	
1101	1201	2.00	0.20	13		ENLARGE PORT LN2 LHE LINERS	0.38	
1201	1301	2.00	0.50	7	THOMAS	ENLARGE PORT LN2 LHE LINERS	-0.80	
211	1002	-0.	-0.	-0			-0.	
1002	1102	2.00	0.50	13		LHE PLUMBING REVISION	-0.91	Third level nodes
1102	1202	1.00	0.50	13		LHE PLUMBING REVISION	0.50	
1202	1302	1.00	0.50	13		LHE PLUMBING REVISION	0.50	
1102	1302	2.00	0.50	11		LHE PLUMBING REVISION	0.80	
1102	1202	1.00	1.00	14		LHE PLUMBING REVISION	0.80	
1302	1402	2.00	0.50	7	CHARG	LHE PLUMBING REVISION	0.60	

Fig. 5. Three-level node input.

experimental physics) or overhead jobs to which a number of people are assigned (e.g., pellet testing).

The second-level nodes are comprised of three digits; the first digit signifies either a starting node for a subsystem or an ending node for a subsystem; the second digit signifies the order within a subsystem; and the last digit signifies the subsystem number. We used a different subsystem for each account number of the baseball project. By having more than one starting and one ending node in a subsystem, we could schedule jobs to start and end at different times during the project and still remain within the maximum computational limit of activities (15) that may leave a node when the scheduling option is used. Also, a task can be rescheduled by changing only the starting node of the first activity and the ending node of the last activity, instead of every node within the path.

The third-level nodes contain four digits, in which the first two indicate the order of activities within a job and the last two are the number of the task. In general, we tried to have at least one node for each three weeks of a tasks' duration. The input for the three node levels is shown in Fig. 5.

Output

Figure 6 shows a typical list of the jobs for which an individual is responsible. This listing was run to show the earliest start and completion dates for a given activity. The same output was generated for the latest start and completion dates. Together, these two outputs give the time in which a job can be run. The same data is sorted for the individual craft codes (Fig. 7). For the craft code case, both early and late start and completion times are given for each activity. The free float is used to measure the float for an activity with respect to all other activities within the task. It is non-zero if a delay in the schedule date of an activity also delays an activity to which it is connected. The program output also gives the cost of the individual activities and the accumulated cost to that time.

Results

The earliest and latest completion dates, along with the actual completion dates, are shown in Table II for some of the 9^ tasks. The actual completion dates

SCHEDULED DATES

I	J	JOB DESCRIPTION	PERSON RESP.	CRAFT CODE	NUMBER OF MEN	DURATION (WEEKS)	START	FINISH	FLOAT
1314	1414	MAGNETIC SHIELDING	CHARG	4	0.5	3.0	17MAR75	7APR75	10.0
1314	1414	MAGNETIC SHIELDING	CHARG	3	0.5	2.0	17MAR75	31MAR75	11.0
1414	1514	MAGNETIC SHIELDING	CHARG	7	0.3	3.0	7APR75	28APR75	10.0
1403	1503	LASER/PELLET PORTS	CHARG	7	0.5	2.0	21APR75	5MAY75	10.0
1516	1616	NEUTRALIZER	CHARG	3	3.0	3.0	12MAY75	3JUN75	2.0
1616	1716	NEUTRALIZER	CHARG	7	0.3	3.0	3JUN75	24JUN75	2.0
1072	1172	MICROWAVE INTERFEROMETER	CHARG	5	0.3	3.0	3JUN75	24JUN75	3.0
1616	1716	NEUTRALIZER	CHARG	4	0.5	2.0	3JUN75	17JUN75	3.0
128	31	LIQUIFIER	CHARG	1	1.7	3.0	10JUN75	1JLY75	0.
128	31	LIQUIFIER	CHARG	2	2.4	3.0	10JUN75	1JLY75	0.
128	31	LIQUIFIER	CHARG	3	0.1	3.0	10JUN75	1JLY75	0.
128	31	LIQUIFIER	CHARG	4	0.1	3.0	10JUN75	1JLY75	0.
28	31	LIQUIFIER	CHARG	5	0.1	3.0	10JUN75	1JLY75	0.
128	31	LIQUIFIER	CHARG	6	0.2	3.0	10JUN75	1JLY75	0.
28	31	LIQUIFIER	CHARG	8	0.8	3.0	10JUN75	1JLY75	0.
28	31	OPERATIONS	CHARG	1	1.0	3.0	10JUN75	1JLY75	0.
28	31	OPERATIONS	CHARG	3	0.5	3.0	10JUN75	1JLY75	0.
28	31	OPERATIONS	CHARG	5	0.5	3.0	10JUN75	1JLY75	0.
28	31	OPERATIONS	CHARG	4	1.0	3.0	10JUN75	1JLY75	0.
28	31	OPERATIONS	CHARG	8	0.5	3.0	10JUN75	1JLY75	0.
1044	1144	ACCESS PLATFORM	CHARG	3	1.0	2.0	17JUN75	1JLY75	0.
1170	1270	GRANITE TABLE	CHARG	1	0.5	2.0	17JUN75	1JLY75	0.0
1159	1259	BELLOWS/INTERFACE/PELLET	CHARG	4	0.4	2.0	17JUN75	1JLY75	2.0
1159	1259	BELLOWS/INTERFACE/PELLET	CHARG	3	0.5	1.0	17JUN75	24JUN75	3.0
1224	1324	BEAM ALIGNMENT/SOURCE	CHARG	7	0.5	2.0	24JUN75	9JLY75	0.
1049	1149	SYSTEM COMPATIBILITY	CHARG	5	0.5	2.0	24JUN75	9JLY75	0.0
1174	1274	DIAMAGNETIC LOOP	CHARG	5	0.5	2.0	24JUN75	9JLY75	0.0
1172	1272	MICROWAVE INTERFEROMETER	CHARG	3	0.8	2.0	24JUN75	9JLY75	3.0
1144	1244	ACCESS PLATFORM	CHARG	3	1.0	1.0	1JLY75	9JLY75	0.
1144	1244	ACCESS PLATFORM	CHARG	4	0.5	1.0	1JLY75	9JLY75	0.
1302	1402	LHE PLUMBING REVISION	CHARG	7	0.5	2.0	1JLY75	16JLY75	0.0
1441	1541	BELLOWS INTERFACE/LASER/MAIN	CHARG	1	1.0	2.0	1JLY75	16JLY75	0.0
1288	1388	LN2 SYSTEM/FACILITIES	CHARG	3	0.5	2.0	1JLY75	16JLY75	0.
1288	1388	LN2 SYSTEM/FACILITIES	CHARG	2	1.0	2.0	1JLY75	16JLY75	0.
1288	1388	LN2 SYSTEM/FACILITIES	CHARG	4	0.5	2.0	1JLY75	16JLY75	0.

Fig. 6. Supervisor responsibility output.

LISTING FOR CRAFT CODE 3

I	J	JOB DESCRIPTION	CRAFT CODE	PERSON RESP.	BEGIN EARLY	BEGIN LATE	NO. WEEKS	NO. MEN	COMPLETE EARLY	COMPLETE LATE	FLOAT FREE	FLOAT TOTAL
1239	1339	MOUNTS FOR FOCUSING MIRRORS	3	FRANK	7FEB75	24JUN75	1.0	1.2	14FEB75	1JLY75	0.	11.0
1314	1414	MAGNETIC SHIELDING	3	CHARG	17MAR75	3JUN75	2.0	0.5	31MAR75	17JUN75	1.0	[illegible]
1167	1267	INTERFACE/MAIN TANK/ROOM	3	DENHOY	7APR75	23JLY75	1.0	0.5	14APR75	30JLY75	1.0	15.0
1168	1268	ACCESS TO PELLET GENERATOR	3	DENHOY	7APR75	23JLY75	1.0	0.5	14APR75	30JLY75	1.0	15.0
1169	1269	ACCESS TO LASER	3	DENHOY	7APR75	23JLY75	1.0	0.5	14APR75	30JLY75	1.0	15.0
1150	1250	TRIGGERING SYSTEM	3	FRANK	14APR75	1JLY75	2.0	0.8	28APR75	16JLY75	0.	11.0
1516	1616	NEUTRALIZER	3	CHARG	12MAY75	27MAY75	3.0	3.0	3JUN75	17JUN75	0.	2.0
1243	1343	MOUNTS FOR MIRRORS	3	FRANK	12MAY75	17JUN75	2.0	1.0	27MAY75	1JLY75	0.	5.0
1437	1537	200 J LASER	3	FRANK	12MAY75	24JUN75	1.0	2.0	19MAY75	1JLY75	0.	6.0
1181	1281	FAST ION GAUGE	3	STACK	27MAY75	27MAY75	3.0	0.5	17JUN75	17JUN75	0.	0.
1340	1440	SUPPORT STRUCTURE	3	FRANK	3JUN75	3JUN75	2.0	3.0	17JUN75	17JUN75	0.	0.0
1073	1173	END LOSS DETECTORS	3	THOMAS	3JUN75	3JUN75	3.0	0.8	24JUN75	24JUN75	0.	0.
1079	1179	FAST ATOM DETECTOR	3	THOMAS	3JUN75	24JUN75	3.0	0.7	24JUN75	16JLY75	0.	3.0
128	31	PELLET TESTING	3	DENHOY	10JUN75	10JUN75	3.0	2.4	1JLY75	1JLY75	0.	0.
128	31	LIQUIFIER	3	CHARG	10JUN75	10JUN75	3.0	0.1	1JLY75	1JLY75	0.	0.
28	31	OPERATIONS	3	CHARG	10JUN75	10JUN75	3.0	0.5	1JLY75	1JLY75	0.	0.
1158	1258	VALVE/BELLOWS/PELLET	3	DENHOY	10JUN75	17JUN75	2.0	0.5	24JUN75	1JLY75	0.	1.0
1160	1260	INSTRUMENTS & ALIGNMENT/PELLET	3	DENHOY	10JUN75	9JLY75	1.0	1.0	17JUN75	16JLY75	0.	4.0
1044	1144	ACCESS PLATFORM	3	CHARG	17JUN75	17JUN75	2.0	1.0	1JLY75	1JLY75	0.	0.
1154	1254	VACUUM SYSTEM/PELLET	3	DENHOY	17JUN75	17JUN75	2.0	0.5	1JLY75	1JLY75	0.	0.
1342	1442	MIRRORS	3	FRANK	17JUN75	17JUN75	3.0	0.1	9JLY75	9JLY75	0.	0.0
1159	1259	BELLOWS/INTERFACE/PELLET	3	CHARG	17JUN75	9JLY75	1.0	0.5	24JUN75	16JLY75	1.0	3.0
1157	1257	PELLET GENERATOR MODIFICATION	3	DENHOY	17JUN75	16JLY75	2.0	1.0	1JLY75	30JLY75	0.	4.0
1260	1360	INSTRUMENTS & ALIGNMENT/PELLET	3	DENHOY	17JUN75	16JLY75	2.0	1.0	1JLY75	30JLY75	0.	4.0
1061	1161	MECHANICAL SUPPORTS/PELLET	3	DENHOY	24JUN75	24JUN75	3.0	0.5	16JLY75	16JLY75	0.	0.
1173	1273	END LOSS DETECTORS	3	THOMAS	24JUN75	24JUN75	3.0	0.8	16JLY75	16JLY75	0.	0.
1176	1278	PLASMA ATTENUATION DETECTOR	3	THOMAS	24JUN75	9JLY75	2.0	0.8	9JLY75	23JLY75	0.	2.0
1172	1272	MICROWAVE INTERFEROMETER	3	CHARG	24JUN75	16JLY75	2.0	0.8	9JLY75	30JLY75	0.	3.0
1144	1244	ACCESS PLATFORM	3	CHARG	1JLY75	1JLY75	1.0	1.0	9JLY75	9JLY75	0.	0.
1254	1354	VACUUM SYSTEM/PELLET	3	DENHOY	1JLY75	1JLY75	2.0	0.5	16JLY75	16JLY75	0.	0.
1288	1388	LN2 SYSTEM/FACILITIES	3	CHARG	1JLY75	1JLY75	2.0	0.5	16JLY75	16JLY75	0.	0.

Fig. 7. Craft code output.

Table II. Project management completion dates.

Task No.	Title	Completion dates: Earliest scheduled	Latest scheduled	Actual
7.	Exit port in liners	Jan. 31	Jan. 31	Jan. 30
11.	50A Source and installation	June 3	June 3	July 11
13.	Source mounting steering	Feb. 14	March 31	Jan. 31
17.	Reenterant box liner	Feb. 14	March 31	March 31
18.	View port	March 17	March 31	March 31
23.	Bellows/source/maintank	Jan. 14	Feb. 14	Feb. 7
27.	Reenterant box spacers	March 31	June 3	March 31
28.	Interconnection cable/source	July 9	July 9	July 1
33.	Modify PS Modules	June 17	June 17	May 30
35.	Debug power supply	June 3	June 3	May 23
36.	Vacuum system source	June 24	June 24	June 19
37.	200 J laser	June 17	July 30	July 14
38.	Focusing mirrors	Aug. 27	Aug. 27	Oct. 2*
39.	Mounts for focusing mirrors	Aug. 27	Aug. 27	Sept. 8
40.	Support structure	July 30	July 30	July 7
41.	Bellows interface/laser/main	July 30	July 30	Aug. 8
42.	Mirrors	July 30	July 30	Oct. 2*
45.	Safety enclosure	Oct. 2	Oct. 2	Oct. 2
54.	Vacuum system pellet	Oct. 9	Oct. 9	NC
58.	Valves/bellows/pellet	Sept. 18	Sept. 25	Sept. 25
61.	Mechanical supports	Sept. 25	Sept. 25	Sept. 12
65.	Acceptance room	Aug. 27	Sept. 4	Aug. 19
70.	Granite table	June 17	June 17	May 30
76.	High speed photo	Dec. 5, 1975	June 21, 1976	NC

Notes:

*delayed in outside fabrication

NC - Not completed as of Oct. 3

generally were within two weeks of the scheduled completion dates. This is very accurate when one considers that the last management run for changing nodes and dates was made on January 22, approximately 9 months prior to the completion of the later tasks. However, this output was used by the engineers and project planners for the majority of the management decisions; therefore, fairly close agreement was anticipated. The cost of the project, on a monthly basis, was within 2% of the scheduled expenditures through the last fiscal year. No comparison has been made since that time.

Conclusion

The most important aspect of project management and project planning with CPM is the organization it requires for use. When one makes estimates for the project planning runs, refines that output and makes more specific estimates for the project management runs, the project is scheduled so that updates and changes can be made in a manner that does not delay the project completion. The output from CPM is then mainly useful in reports and budgetary planning from the project planning runs and for the organization and scheduling of tasks to be done by the various crafts or individuals from the project management runs. Budgetary constraints can also be handled by CPM. However, more importance is placed on the scheduling of tasks and people than on the scheduling of money.

On the Baseball II-T system, the project planning for phase 2 runs were completed in two weeks at a cost of about four man-weeks of engineering. The initial setup for the project management runs for the first phase required approximately five man-weeks (including the estimates and selection of a node schedule), and was completed in three weeks. At first, weekly updates were made for the management runs (with an engineering cost of approximately three man-days for each update), until the CPM output was very close to the actual schedule of events prior to that time. We feel that at least two CPM runs are necessary to align any CPM model to the actual chain of events. The total cost of these management techniques used on the Baseball system was less than 1% of the overall project cost. The difference in cost between CPM and other management techniques is not significant.

The results of the CPM modeling on the Baseball II-T system were most encouraging. After the fourth update, the money schedules and craft codes schedules were consistent with the project data up to that point. Cost overruns for the past fiscal year were averted by rescheduling some jobs from the past fiscal year to the present. Also, when milestones would not be met with the model, they were generally not met on the project unless changes to the project schedule were made.

References

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